

Perception and Practice on Electronic Waste Disposal among Medical Students in a Tertiary Care Centre

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ABSTRACT

Background: Electronic waste (E-waste) is one of the fastest-growing waste streams worldwide and poses significant environmental and public health challenges due to the presence of hazardous substances. Medical students, as future healthcare professionals, are expected to play a key role in promoting environmentally responsible practices. However, information regarding their perception and disposal practices related to E-waste remains limited.

Objectives: To assess the perception and practices related to E-waste disposal among medical students and determine factors associated with E-waste disposal practices.

Materials and Method: A cross-sectional study was conducted among 227 undergraduate medical students of a private medical college over a period of two months. A multistage sampling technique was employed, wherein students were stratified by year of study and selected using simple random sampling without replacement through a computer-generated random number method. Data were collected using a pre-validated, structured, self-administered questionnaire assessing perception, knowledge, and practices related to e-waste. Data were analyzed using Epi Info version 7.2.2.6. Descriptive statistics were expressed as frequencies, percentages, means, and standard deviations. Chi-square test, independent t-test, ANOVA, and multiple linear regression were used to identify factors associated with practice scores.

Results: Among the participants, 63.0% had heard about e-waste, while 81.5% recognized that discarded electronic devices could cause environmental hazards. Perception regarding hazardous components requiring special treatment was reported by 68.3%, whereas only 26.9% were aware of E-waste policies in India. Separate E-waste collection services were reported by only 15.4% of participants. Despite moderate perception, safe disposal practices were suboptimal, with many participants storing unused devices or disposing of them through informal means. Multiple linear regression analysis revealed that female gender ($B=2.43$, $p=0.045$) and household size ≤ 4 adults ($B=1.75$, $p=0.001$) were significant predictors of better E-waste disposal practices.

Conclusion: Although medical students demonstrated moderate perception regarding E-waste and its hazards, detailed knowledge, policy awareness, and safe disposal practices remain inadequate. The persistence of a knowledge–practice gap highlights the need for curriculum-based environmental education, institutional E-waste management systems, and targeted behaviour change interventions to promote responsible E-waste disposal practices.

Keywords: Electronic waste, E-waste management, Medical students, Perception, Disposal practices, Environmental health.

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INTRODUCTION

Electronic waste (e-waste) refers to discarded electrical and electronic equipment that has reached the end of its useful life, including devices such as mobile phones, computers, televisions,

and household appliances. With rapid technological advancement, increased consumer demand and shortened product life cycles, E-waste has emerged as one of the fastest-growing waste streams globally. The Global E-waste Monitor estimated that 53.6 million metric tonnes of E-waste were generated

worldwide in 2019, with projections indicating a continuous rise in the coming years.¹

E-waste contains hazardous substances such as lead, mercury, cadmium, and brominated flame retardants, which pose serious environmental and health risks if not managed properly. Improper disposal practices, including open burning, landfilling, and informal recycling, lead to the release of toxic substances into the environment. Exposure to such contaminants has been associated with neurological, respiratory, and developmental health effects, particularly among vulnerable populations.²

India is one of the world's leading generators of E-waste, owing to rising urbanization, digitalization, and expanded access to electronic gadgets. The amount of e-waste produced in India has been rising significantly, according to national reports, creating a serious threat to the environment and public health.³ Despite the implementation of legislative frameworks like the E-Waste (Management) Rules, 2022, there is still a lack of effective enforcement and public awareness.⁴

Several studies have explored awareness and practices related to E-waste among students and the general population, reported that while students frequently used electronic devices, awareness regarding safe E-waste management was inadequate, particularly regarding proper disposal and generation of e-waste.⁵ International studies further support these findings, emphasizing the need for improved educational interventions.^{6,7}

Medical students are expected to play a vital role in advancing sustainable practices and environmental health as future healthcare providers. Therefore, the current study was conducted to evaluate the perceptions of e-waste, their disposal practices and its associated factors among medical students in a tertiary care centre at Puducherry.

METHODOLOGY

A cross-sectional study was conducted among undergraduate medical students in a private tertiary care teaching institution in Puducherry. The study was carried out over a period of six months, after obtaining necessary institutional permissions. Approval was obtained from the Institutional Scientific Research Committee and the Institutional Ethics Committee prior to the commencement of the study. Participation was voluntary, and informed consent was obtained from all participants. Confidentiality and anonymity were strictly maintained throughout the study. The study population included undergraduate MBBS students from all academic years (Phase I to Final Year) who were present during the study period. Students aged ≥ 18 years, willing to participate and provided informed consent were included. Those who were not available during data collection, chronic absentees were excluded.

SAMPLE SIZE CALCULATION

The sample size was calculated using the Open epi software

Where:

$Z = 1.96$ (95% confidence level)

$p = 18\%$ ⁵

$d = 5\%$ (absolute precision)

Thus, the calculated sample size was 227.

SAMPLING TECHNIQUE

A multistage sampling technique was employed. In the first stage, the study population was stratified based on the year of study (Phase I to Final Year) to ensure representation across all academic levels. In the second stage, a sampling frame of students from each academic year was prepared. Participants were then selected from each stratum using simple random

sampling without replacement, with the help of a computer-generated random number table. The number of students selected from each academic year was proportionate to the total number of students in that year. Eligible students who consented to participate were included until the required sample size of 227 was achieved.

STUDY TOOL

Data were collected using a pre-validated, structured, self-administered questionnaire, developed based on literature review and expert input. The questionnaire consisted of the following sections:

1. Socio-demographic Details

2. Perception towards E-waste and its Hazards was assessed using Likert-scale (Environmental impact of e-waste, Responsibility for proper disposal, Perception of institutional and governmental roles, Willingness to adopt safe disposal practices)

3. Practices Related to E-waste Disposal (Methods of disposal, Handling of damaged electronic devices, Perception and utilization of recycling facilities)

VALIDATION AND RELIABILITY

The questionnaire was pre-tested among approximately 10% of the study population in a similar setting. Necessary modifications were made based on feedback. Content validity was ensured through expert review. Internal consistency of perception items was assessed using Cronbach's alpha, and a value of 0.82 was considered acceptable.

DATA COLLECTION PROCEDURE

Data collection was carried out during regular college hours. The purpose of the study was explained to the participants and informed consent was obtained. The questionnaire was distributed and collected after completion, ensuring privacy and independent responses.

STATISTICAL ANALYSIS

The collected data were entered into Microsoft Excel and analyzed using Epi Info version 7.2.2.6. Descriptive statistics were used to summarize the data, with continuous variables expressed as Mean and Standard Deviation and categorical variables presented as frequencies and percentages. Inferential statistics were applied to assess associations and differences between variables. The Chi-square test was used to evaluate the association between categorical variables. For comparison of mean scores between two groups, the independent t-test was used for normally distributed data, while the Mann-Whitney U test was applied for non-normally distributed data. For comparisons involving more than two groups, one-way analysis of variance (ANOVA) was used for normally distributed data and the Kruskal-Wallis test was used for non-parametric data. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 227 participants were included in the study. The majority were female (70.9%) and most belonged to urban areas (85.0%). A large proportion of participants were from socioeconomic Class I (88.5%), only a small fraction in Class II (09.3%) and Class III (02.2%) according to Modified B.G. Prasad's classification of socio-economic status⁸. Most participants reported having fewer than four family members (86.3%). Nearly all participants predominantly used mobile phones (96.5%) as their primary electronic device. Regarding current gadget usage, 43.6% used one device, while a smaller proportion (20.7%) reported using multiple devices. Notably, 15.9% had not used any gadgets till date (Table 1).

Table 1: Socio-Demographic Characteristics of Participants (n= 227)

Variables in categories	Variables in categories	Frequency (n)	Percentage (%)
Gender	Male	66	29.1
	Female	161	70.9
Place of Residence	Rural	34	15.0
	Urban	193	85.0
Socio-economic Class	Class I	201	88.5
	Class II	21	9.3
	Class III	5	2.2
Number of family members present	<4	196	86.3
	>4	31	13.7
Gadget used frequently	Mobiles / its accessories	219	96.5
	Computer/laptop	5	2.2
	Others	3	1.3
Number of gadgets currently in use out of those purchased in past 2 years	1	99	43.6
	2	39	17.2
	3 and more	6	2.6
	All	47	20.7
	Nil	36	15.9

Perception towards E-waste showed among 63.0% had heard about e-waste, only 22.9% were aware of what happens to electronic devices after disposal. A very small proportion (05.7%) knew the amount of E-waste they generated annually. A majority (81.5%) recognized that discarded E-waste poses environmental hazards and 68.3% were aware that some hazardous components of E-waste need special treatment in order to be safely disposed of. Additionally, 76.7% knew that some parts could be recycled for profit. However, perception of

systemic aspects was low, with only 15.4% reporting separate collection of E-waste in their area and 13.2% aware of institutional policies for disposal of e-waste. Unfortunately, less than half (42.3%) expressed willingness to hand over E-waste to authorized collectors. This shows although general perception about environmental hazards of E-waste is relatively high, there is a significant gap in practical knowledge, policy awareness and disposal systems, highlighting the need for targeted educational and institutional interventions (Table 2).

Table 2: Perception on E-waste Disposal among the participants (n= 227)

Responses	Yes n (%)	No n (%)
Do you consider used electronic devices as waste?	68 (30.0)	159 (70.0)
Do you think it is important to know about the status of electronic devices after disposal?	52 (22.9)	175 (77.1)
Are you familiar with the concept of e-waste?	143 (63.0)	84 (37.0)
Do you think individuals have a responsibility to know how much e-waste they generate?	13 (5.7)	214 (94.3)
Do you think E-waste causes environmental harm?	185 (81.5)	42 (18.5)
Do you believe e-waste contains hazardous materials?	155 (68.3)	72 (31.7)
Do you think e-waste recycling can provide economic benefits?	174 (76.7)	53 (23.3)
Do you think e-waste is collected separately in residential area?	35 (15.4)	192 (84.6)
Would you give E-waste to authorized collectors?	96 (42.3)	131 (57.7)
Do you think institution have an E-waste policy?	30 (13.2)	197 (86.8)
Do you think E-waste policies are there in India?	61 (26.9)	166 (73.1)

Table 3: E-waste Disposal Practices among Medical Students (n= 227)

Variables in category	Variables in category	Frequency (n)	Percentage (%)
Disposal method of electronic devices	Sell	47	20.7
	Dispose with household waste	56	24.7
	Donate	117	51.5
	Keep for future use	7	03.1
Number of mobile phones purchased in the past 2 years	One	63	27.8
	Two	86	37.9
	Three	55	24.2
	More than three	23	10.1
Reasons for purchasing a new mobile phone	Upgrading	198	87.2
	Repair	16	07.0
	Peer influence	13	05.8
Frequency of replacing electronic devices	Every 6 months	14	06.2
	Every 12 months	41	18.1
	Every 18 months	37	16.3
	Every 24 months	135	59.5
Perceived barriers to proper E-waste management	High cost	80	35.2
	Lack of awareness	14	06.2
	Lack of collection/ recycling facilities	5	02.2
	Inadequate legislation	26	11.5
	All the above	102	44.9

Pertaining to disposal practices, 51.5% of participants donated their electronic devices, while 24.7% disposed of them with household waste. About 37.9% of participants had purchased at least two mobile phones in the past two years. Device replacement was most commonly reported every 24 months once

(59.5%) and the predominant (87.2%) reason being upgradation of gadgets to better featured. When asked about perceived barrier to proper E-waste management, the most frequent response was “all of the above” (44.9%), indicating lack of awareness, lack of collection or recycling facilities, inadequate legislation (Table 3).

Table 4: Comparison of Mean Practice Score with Socio-Demographic Variables (n = 227)

Variables in Category	Variables in Category	n	Mean ± SD	Test Statistic	p-value
Sex	Male	66	4.24 ± 2.30	t = 5.39	0.021*
	Female	161	4.55 ± 1.81	t = 5.39	0.021*
Residence	Rural	34	4.47 ± 2.08	t = 0.04	0.968
	Urban	193	4.46 ± 1.95	t = 0.04	0.968
Number of Adults in the family	≤4	196	4.55 ± 1.98	t = 2.79	0.007*
	>4	31	3.87 ± 1.76	t = 2.79	0.007*
Socioeconomic Status	Class I	201	4.53 ± 2.02	F = 1.46	0.235
	Class II	21	3.76 ± 1.44	F = 1.46	0.235
	Class III	5	4.60 ± 0.89	F = 1.46	0.235
Number of Gadgets in Use	1	99	4.68 ± 2.04	F = 0.84	0.502
	2	39	4.10 ± 2.58	F = 0.84	0.502
	≥3	89	4.40 ± 1.70	F = 0.84	0.502

The mean practice score across certain socio-demographic variables showed Female participants had a significantly higher mean practice score compared to males (4.55 ± 1.81 vs. 4.24 ± 2.30; p = 0.021). Similarly, participants from families with less

than four members had higher practice scores (p = 0.007). No statistically significant differences were observed with respect to place of residence (p = 0.968), socioeconomic status (p = 0.235), or number of gadgets in use (p = 0.502) (Table 4).

Table 5: Multiple Linear Regression Analysis of Factors Associated with Practice Score (n = 227)

Variables	Category	Unstandardized B	Std. Error	Standardized Coefficient B	t	Sig.
Gender	Female vs Male	2.43	1.14	0.04	2.11	0.045
Number of adults in family	< 4 vs > 4	1.75	0.16	0.12	10.94	0.001

Multiple linear regression analysis showed that female gender (B = 2.43, p = 0.045) and having fewer than four family members (B = 1.75, p < 0.001) were independently associated with higher practice scores. After adjusting for other variables, gender and family size remained significant predictors, indicating that these factors independently influence E-waste management practice (Table 5).

DISCUSSION

The present study assessed the perception, knowledge of hazards, and disposal practices related to electronic waste among medical students. The findings revealed that although a majority of participants had basic awareness and perception regarding E-waste and its environmental impact, detailed knowledge, policy awareness, and safe disposal practices were inadequate. A clear gap between perception and actual behavior was observed, a finding consistently reported in previous study by Borthakur and Singh.⁹

In terms of perception, 81.5% of participants were perceived the environmental risks associated with e-waste, and 63.0% of participants had heard of it. Nonetheless, knowledge of the policy framework (26.9%), yearly E-waste generation (05.7%), and post-disposal procedures (22.9%) remained inadequate. Nannaware and Kulkarni reported similar results, noting that while students used electronics on a regular basis, their knowledge of appropriate e-waste management techniques was lacking.⁵ Similarly, Kshtriya and Raghupathy noted deficiencies in health science students' knowledge, attitudes, and behaviors, especially with regard to appropriate disposal and policy awareness.⁶ Yee et al.'s recent study among medical students also showed that awareness does not always translate into suitable practices, underscoring the continued existence of the knowledge-practice divide.⁷

Regarding health hazards, the current survey revealed that 68.3% of participants were aware that hazardous fractions need particular handling, and 76.7% were aware that electronic components can be recycled for financial gain. However, there was still a lack of knowledge about the scope and lifecycle of e-waste, which was indicative of a shallow comprehension. In a similar vein, Krishnamoorthy et al. stressed that while toxicity is known, little is known about its long-term effects on the environment and human health.¹⁰ Additionally, global data from the World Health Organization shows that exposure to e-waste

affects the neurological, respiratory, and developmental health, highlighting the necessity of thorough awareness.¹¹

Despite moderate perception, disposal practices were found to be suboptimal. A considerable proportion of participants reported disposing of E-waste along with household waste or storing unused devices. Only 15.4% reported availability of separate E-waste collection systems, and willingness to adopt safe disposal practices was limited (42.3%). These findings are consistent with those of Maphosa et al., who reported that university students demonstrated moderate perception but poor disposal practices.¹² Similarly, Mittal et al. observed that medical students commonly store or exchange devices rather than utilizing formal recycling systems.¹³ Dutta et al. further highlighted that inadequate infrastructure and reliance on informal recycling sectors contribute significantly to unsafe E-waste disposal practices in India.¹⁴

Although most participants recognized the environmental hazards of e-waste, awareness of its potential health consequences neurological, respiratory, endocrine, and developmental disorders remained limited. Grant et al., in a systematic review, reported significant health risks associated with exposure to toxic substances released from e-waste.¹⁵

Multiple linear regression analysis identified female gender and household size ≤4 adults as significant predictor of better E-waste disposal practices. Female students demonstrated higher practice scores, a finding consistent with previous studies reporting greater environmental responsibility among females.¹⁶ Students from smaller households also had better practice scores, possibly due to greater individual accountability in managing electronic devices.

CONCLUSION

Although medical students generally recognize e-waste and its hazards, they lack practical knowledge about safe disposal methods and current regulations. This reflects a clear gap between theoretical awareness and real-world application. Bridging that gap will require hands-on education and supportive systems that promote effective E-waste management.

RECOMMENDATIONS

Integrating E-waste management into the medical curriculum, with establishing simple institutional collection systems, can encourage safer practices. Regular Behaviour Change and

Communication activities, improved visibility of national policies and collaboration with authorized recycling agencies are essential to promote responsible and sustainable E-waste disposal.

LIMITATIONS

This study is self-reported, cross-sectional and conducted in single institution, limits generalizability. This may have reduced variability in responses. Additionally, reliance on self-reported data may not fully reflect actual practices, and certain contextual factors such as availability of E-waste facilities or prior environmental exposure were not assessed.

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